



KL ENGINEERING, INC.

DESIGN | FABRICATE | INTEGRATE

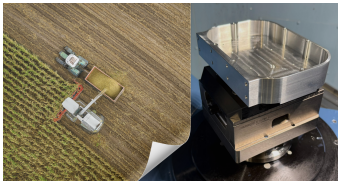


SCALABLE DESIGN AND MANUFACTURING FOR AUTONOMOUS AGRICULTURE ASSEMBLIES BACKGROUND

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Autonomous agriculture is rapidly transforming modern farming practices, with advanced vehicles and robotic systems automating tasks that were previously dependent on manual labor. At the core of these systems are highly integrated assemblies that combine ruggedized housings, sensors, electronics, and precision mechanics, designed to survive extreme outdoor environments while delivering reliable and repeatable performance.

Our customer, a leading innovator in the autonomous agriculture sector, approached us at the earliest stages of their product development. They had developed a functional in-house prototype of a critical assembly that housed, protected, and aligned sensitive electronic and sensor components. While this prototype successfully demonstrated proof of concept, it was never intended for scalable production.

Several challenges quickly emerged:

The prototype was hand-built by engineers who worked in a lab environment, but it was not manufacturable, repeatable, or field-serviceable for production at scale.

- The assembly would be deployed in multiple locations on a given vehicle, across multiple autonomous vehicle platforms, making weight reduction, cost control, and durability equally critical.
- The assemblies had to withstand farm field conditions (including weather, vibration, and heavy use) without failure.
- The mechanical design needed to be future-proof, outlasting multiple generations of rapidly evolving electronics and sensors.
- The customer wanted to focus on their core competencies of system innovation and electronics design, not on managing mechanical sub-assemblies or building out manufacturing and integration capabilities.

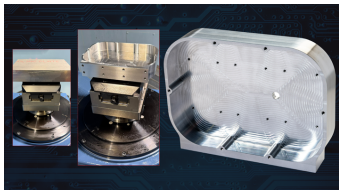
Recognizing these challenges, the customer sought a manufacturing and engineering partner who could translate their early-stage mock-up into a production-ready design. They needed a team capable of design-for-manufacturing (DFM), materials selection, assembly engineering, and scalable production – while also providing flexibility for ongoing design changes and future iterations.

The Challenge

The central challenge was to transform a functional but non-scalable prototype into a manufacturable, repeatable, and cost-efficient product without sacrificing performance. At the same time, the design had to meet demanding requirements for:

- Durability in outdoor agricultural environments
- Weight and cost optimization across multiple assemblies per vehicle
- Ease of field serviceability for sensor and electronics replacement
- Longevity of the mechanical housing despite the rapid evolution of electronic components

In short, the customer required a production-ready design that could bridge the gap between concept and scalable manufacturing, while minimizing complexity and risk on their end.



The Solution

We partnered with the customer to provide a full turnkey design-for-manufacturing (DFM) and integration solution:

1.) Redesign for manufacturability

- (a) Introduced locating datum features, pins, and mechanical design elements to ensure repeatable assembly.
- (b) Re-engineered the housing to simplify manufacturing sequences and fixture design.
- (c) Focused resources on the critical tolerance features that directly impacted system functionality.

2.) Material and process selection

- (a) 6061 aluminum was selected, with hard anodization, for its optimal balance of cost, machinability, corrosion protection, and durability.
- (b) Optimized weight reduction without compromising structural integrity.

3.) Assembly and integration

- (a) Moved from functional mock-ups to first article inspection runs, through to production-level assemblies.
- (b) Designed with serviceability in mind, ensuring that electronic or sensor components could be replaced in the field without replacing the entire unit.
- (c) Allowed for ongoing design iterations while maintaining production capability.

4.) Flexible pilot production

- (a) We acted as the single responsible entity for the full assembly, eliminating the need for the customer to manage multiple suppliers, technicians, or in-house diagnostic testing.
- (b) Provided the capability to support both production units and experimental R&D assemblies on the same line, giving the customer flexibility to test next-generation designs in parallel with existing builds.

Technical Highlights

- **Component complexity:** Small, 5-axis machined aluminum housing—relatively straightforward, but part of a larger family of assemblies requiring both right- and left-hand variants.
- **Tolerance management:** The majority of features were held to standard tolerances; however, critical intersections required precision machining, careful sequencing of operations, and rigorous in-process inspection.
- **Volume ramp-up:** Initial builds were in the hundreds to low thousands, after which high-volume production was transitioned offshore.
- **Lifecycle considerations:** Mechanical housings designed to extend beyond multiple sensor/electronics refresh cycles.

Results

By consolidating design, manufacturing, and assembly responsibilities under one roof, the customer realized several key benefits:

- Accelerated development cycles – rapid DFM, redesign, and iteration.
- Improved cost control – through optimized machining, material selection, and assembly repeatability.
- Reduced internal burden – no need for the customer to maintain an in-house assembly or diagnostic testing team.
- Enhanced flexibility – ability to produce both standard assemblies and R&D configurations simultaneously.
- Scalable production path – from prototypes and pilot production to offshore high-volume manufacturing.

Next Steps

Following the success of the first-generation assemblies, we partnered with the customer on a second-generation design cycle. The new assemblies integrate revised hardware and expanded functionality, with our team once again responsible for manufacturability, pilot production, and scaling support.

